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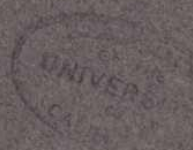
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# OUTLINE INTRODUCTION TO THE MINERAL RESOURCES OF TENNESSEE

Compiled and Written  
BY GEORGE H. ASHLEY



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ON THE MINERAL RESOURCES OF TENNESSEE."

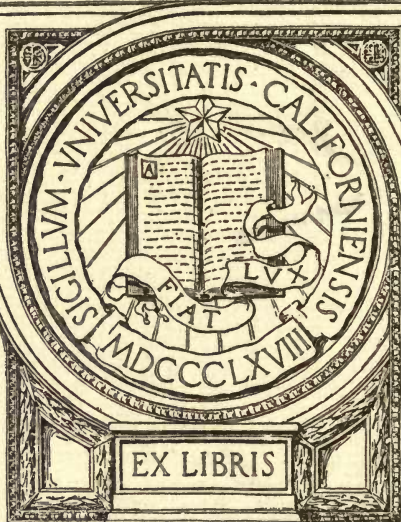


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STATE OF TENNESSEE—STATE GEOLOGICAL SURVEY

GEORGE H. ASHLEY, State Geologist

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# ZINC MINING IN TENNESSEE

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BY

SAMUEL W. OSGOOD

KNOXVILLE, TENN.

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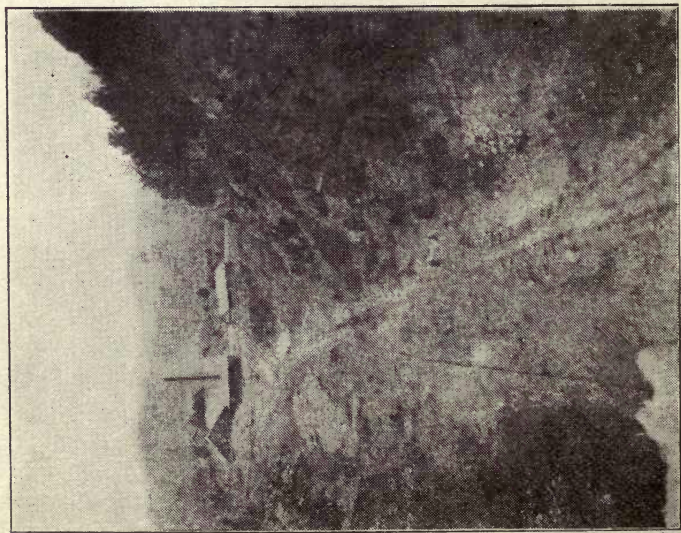


Fig. 1. Lead Mine Bend Zinc Quarry, New Prospect Mine.

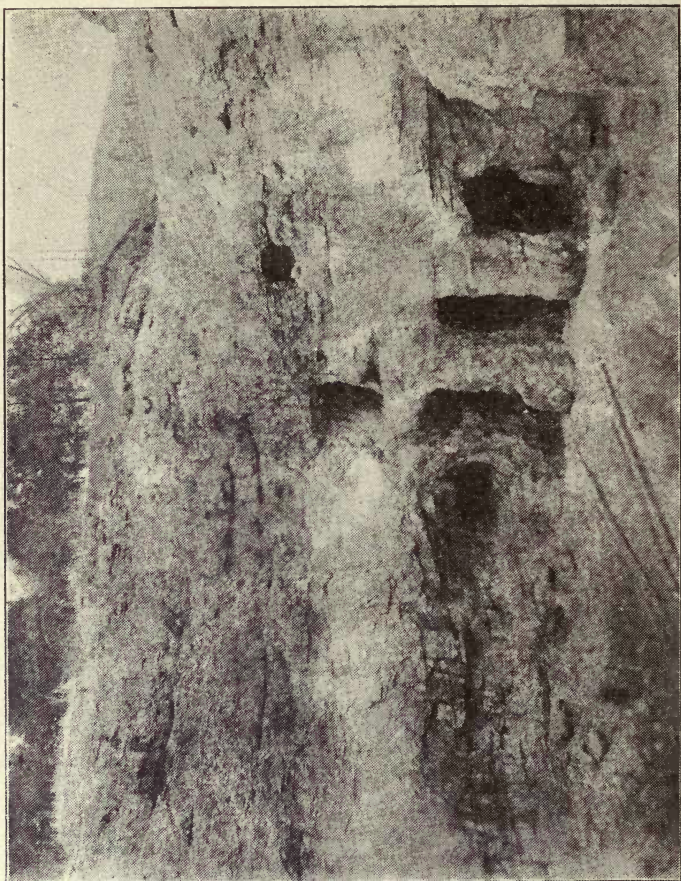


Fig. 2. Lead Mine Bend Zinc Quarry, New Prospect Mine.

STATE OF TENNESSEE—STATE GEOLOGICAL SURVEY

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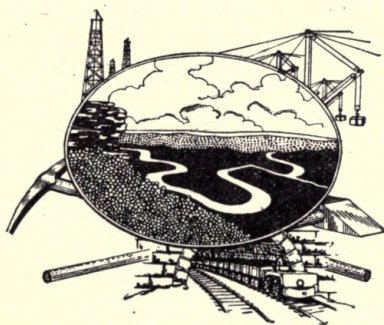
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## CONTENTS

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	PAGE
General description of the district .....	5
Character of ore .....	6
Former methods of working.....	7
The present operations in the district .....	8
Successful milling of Tennessee zinc ores fully proven.....	13
The smelting of Tennessee zinc ores in Tennessee.....	15
Some of the principal articles on zinc in Tennessee.....	18

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## ILLUSTRATIONS

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	PAGE
Plate I, Fig. 1. Lead Mine Bend Zinc Quarry. New Prospect Mine.....	1
Fig. 2. Lead Mine Bend Zinc Quarry. New Prospect Mine.....	1
Plate II, Fig. 1. The Holston Mill at Flat Creek.....	9
Fig. 2. The Holston Mine Shaft.....	9
Plate III, Fig. 1. The Grasselli Chemical Co.'s Zinc Quarry, Newmarket, Tenn.....	10
Fig. 2. The Graselli Chemical Co.'s Zinc Quarry, showing car- bonate ore digging.....	10
Plate IV, Fig. 1. Mossy Creek Zinc Quarry, at Jefferson City, Tenn., of the Eades, Mixter & Heald Zinc Co., now controlled by the Osgood Exploration Co.....	12
Fig. 2. The Branner Zinc Mine and Carson-Newman College Zinc Mine (looking from the Mossy Creek Mine), controlled by the Osgood Exploration Co., at Jeffer- son City, Tenn.....	12

# ZINC MINING IN TENNESSEE

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By SAMUEL W. OSGOOD.

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## GENERAL DESCRIPTION OF THE DISTRICT.

The zinc district of East Tennessee was mapped in the years of 1896 to 1901, and is described in folios issued by the United States Geological Survey at that time. The position of the mines and mineral belts here described is indicated on the map accompanying the part of Bulletin 2, dealing with marble. (Bulletin 2-D.) The maps show the district in general to consist of three nearly parallel zinc belts, 40 to 50 miles long, and about 20 miles apart. These belts are each only a few hundred feet wide, and extend in a northeast-southwest direction, following the general strike of the Appalachian system of folds and faults.

The ores are contained in the Knox dolomite, a formation belonging, in part, to the Silurian and in part to the Cambrian series. In places local disturbances have given rise to cross-fissure zones of fracture. In these zones are the richest ore bodies. The ores are sulphides and they occur in the filling of the fracture zone or breccia, combined with calcite and dolomite and not in the rock. No barytes is present in these ores. Where the clay and sand of the surface is 20 to 30 feet thick, carbonates and silicates are found to overlie the sulphide ores.

The central belt occupies the valley of the Holston River, and is called the Holston Valley zinc belt. This belt has ores containing zinc with no lead and less than 0.5 per cent iron. The more northerly ore bodies, near the Powell River, and the southerly belt, near the French Broad River, carry both iron and lead.

The ore bodies along the northerly belt, which include the district in the vicinity of the Powell River, the Clinch River, and between these two rivers, near the city of New Tazewell, in Claiborne County, and in Union County, are extremely large. The ores are a compact "blende," or what is called zinc sulphide, being mined frequently in huge blocks several feet thick, assaying 45 to 50 per cent zinc. This ore, however, is extremely difficult to mill, but makes a good smelting ore.

As is shown from the photographs of the New Prospect Mine (Plate I), the open quarries, where this ore has been mined, are very extensive.

Straight Creek Mine, near Tazewell, and other mines along this same belt all have bodies of high-grade zinc "blende," which is of the same nature as the above ores, carrying a little iron in the form of pyrite, which, added to its complex milling, also makes it difficult for smelting for the purpose of making spelter or merchant zinc. However, this ore could be smeltered very successfully in a furnace for the purpose of making zinc white paint.

The southerly belt of ore, which lies near the French Broad River, and which has been opened at Leadvale, near White Pine, and Dandridge, in Jefferson County, has a complex mixture of lead and zinc, which is combined in such a fine grained intimate mixture as to make the milling of it impracticable, but which ores when found in sufficiently large bodies would make excellent ore for smelting in a zinc white paint furnace.

Both the northerly belt and the southerly belt have lead, and some iron with the zinc in the ore. It is with the central belt that this article is principally concerned, for on this belt are the most extensive operations, owing to accessibility to the railway, and to the simple nature of the ores, which are more easily treated. The Tennessee Valley ores, which occur near Knoxville, have no lead nor iron in them, and have an established reputation for being chemically pure for this reason.

The Holston Valley zinc belt is about 40 miles long, in a northeast-southwest direction, and from 50 to 700 feet wide. Knoxville is about in the center of the belt. The Southern Railway's double-track line between Bristol and Chattanooga traverses almost the entire length of the belt, hauling large amounts of Tennessee coal from near Knoxville to the coast.

#### CHARACTER OF ORE.

Carbonate ores have been shipped from the district for many years. They occur in a bed of red and yellow clay overlying the dolomite containing the yellowish blende. The shipments of carbonates have been spasmodic, and the future of the district will no doubt depend largely on the success of treating the sulphide ores.

The East Tennessee zinc ores, while remarkable for their chemical purity and freedom from the undesirable iron and lead minerals usually found in zinc ores, have never until recently been of much commercial importance, owing to the low grade of the ore and the methods of milling. Actual results have shown that the cause for the lack of success was the small daily capacity of the plants, the hand-sorting of the ores bringing the cost per ton of ore treated to an abnormally high figure. The crude method of building the mills also made steady

daily operation over long periods impossible because of frequent and costly repairs.

The blende, while in large bodies of a brecciated rock, occurs in bunches or small seams as a filling in the breccia, of the fissure zone. The ore has in the past always been hand-sorted to give a mill feed assaying from 8 to 12 per cent zinc. Recently, however, it is thought to have been demonstrated by large commercial operations that the entire brecciated mass can be mined and milled on a large scale in a modern concentrating mill, maintaining a fair grade of product.

#### FORMER METHODS OF WORKING.

The first mining and milling of the zinc blende ores on any considerable scale was undertaken by the Edes, Mixer and Heald Zinc Company, in 1883, at Mossy Creek, Jefferson County. This first mill was erected to wash the dumps of blende cobbled from the carbonate ores, and was so successful that in 1885 an 80-ton mill, including crusher, rolls and jigs, was erected. This mill treated hand-sorted ore from a large quarry for several years. It was closed in the panic of 1893, but was reopened by the John Weir Lead & Zinc Company in 1900, and operated for a few months. The small daily capacity and the crude equipment brought costs per ton so high that the mill was closed after a few months.

The second of these small unsuitable mills was erected by the Ingalls Zinc Company, about  $1\frac{1}{2}$  miles southeast of Newmarket, in 1898. The ore was quarried from near the surface. Here, again, the ore was hand-sorted, the capacity of the mill being small, like that on Mossy Creek. The ore was hand-sorted to about a 12 per cent zinc before milling, and a high-grade concentrate was shipped, but the operating costs were very high per ton of ore mined, the cause being simply the inconvenient methods for handling too small a daily tonnage.

The third of these small mills was built by the Roseberry Zinc Company, about  $1\frac{1}{2}$  miles west of Mascot, in 1900. This mill was an advance on former plants, but the ore was still hand-sorted in the quarry, one car of waste being secured for each car of ore. It was one of the inefficient, old-style Joplin mills of small capacity, but it shipped many carloads of high-grade zinc concentrates. The capacity was low, the mill inefficient, and poorly built for continuous operation; consequently the costs again were too high for commercial economic results. The ore was mined in a quarry at first, and later a shaft nearly 200 feet deep was sunk, and mining in stopes was begun.

The fourth of these small mills was built by the Holston Zinc Com-

pany, about  $\frac{3}{4}$  mile west of Mascot, in 1903, and this was another advance, especially in the development of a more elaborate jigging system. This mill was, however, of small capacity, and the ore was still hand-sorted in the quarry. In 1905 the shaft was sunk to 150 feet, and underground stope mining was started and milling was done with no hand-sorting, which showed another advance. At this time daily capacity of the mill was small, the operation not in experienced hands, and the costs per ton relatively high.

The Holston Zinc Company's mill, shown in Plate II, Fig. 1, was partially re-equipped in 1907 along lines suggested by A. M. Hewlett, the President of the company, and operated under the writer's management. Mr. Hewlett's untimely death in 1907 had much to do with the Holston Zinc Company's failure to complete the re-equipment of the mill. However, the plant was operated in its incomplete state for several months, and shipments of concentrates were made on a scale not possible before that time in the East Tennessee zinc districts. This showed at once the correctness of Mr. Hewlett's judgment in demonstrating on a commercial scale that all it required to make a success of the Tennessee zinc ores was large capacity to reduce the "per ton" cost, a mill elaborate enough to obtain the zinc in the ore and of a sufficiently stable construction for continuous daily operation. The last year's operations on the Holston zinc belt include, besides those of the Holston Zinc Company, the shipments of carbonate ores and prospecting of its blende ore deposits by the Newmarket Zinc Company, the Grasselli Chemical Company, the Tennessee Mineral Company, and the Osgood Exploration Company.

#### THE PRESENT OPERATIONS IN THE DISTRICT.

At the Holston property the ore is mined through a shaft (Plate II, Fig. 2) at a depth of 160 feet in large stopes 50 to 75 feet wide and carried to a height of 40 feet. Another level has been started above, and drifts have been started to allow of stoping at a considerable distance from the shaft. Mining is done by machine drills, operated by compressed air.

In this mine all rock is taken from the stopes for the entire width, no hand-sorting being done. All ore is dumped into the crushing plant and sent from there to the mill. The mill has three departments—a roughing department, from which a large amount of waste rock formerly picked out by hand is sent to the tailings dump, and both a fine and coarse finishing department.

The Grasselli Company, whose principal office is at Cleveland, O.,

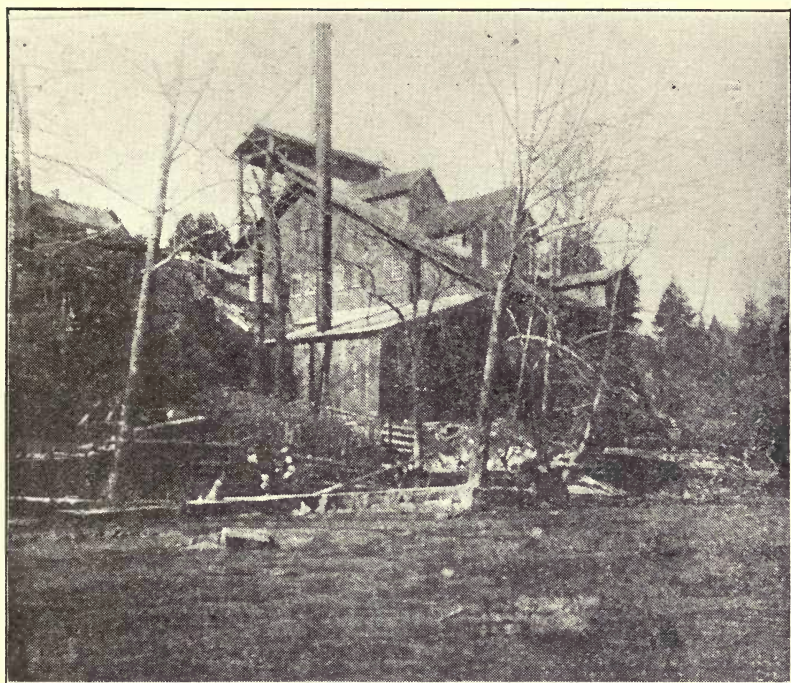


Fig. 1. The Holston Mill at Flat Creek.

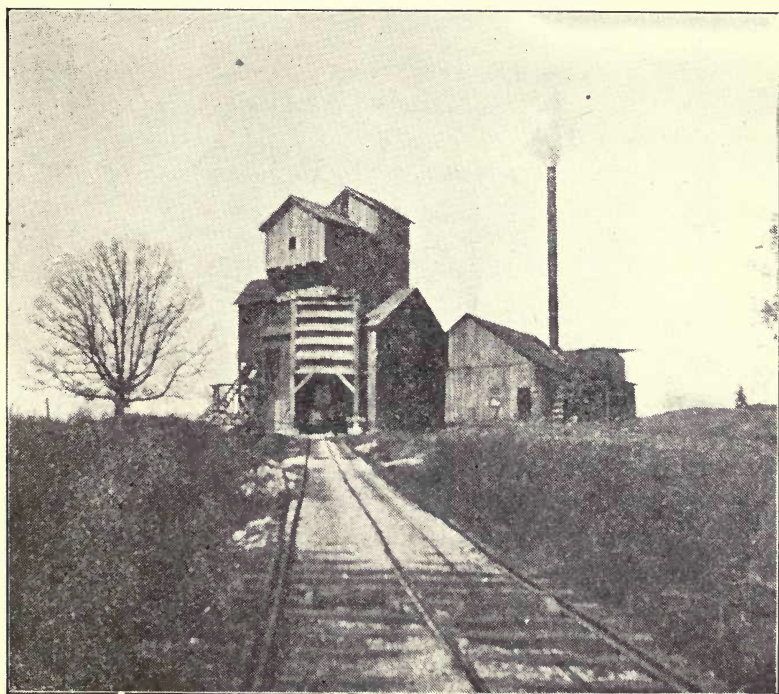


Fig. 2. The Holston Mine Shaft.

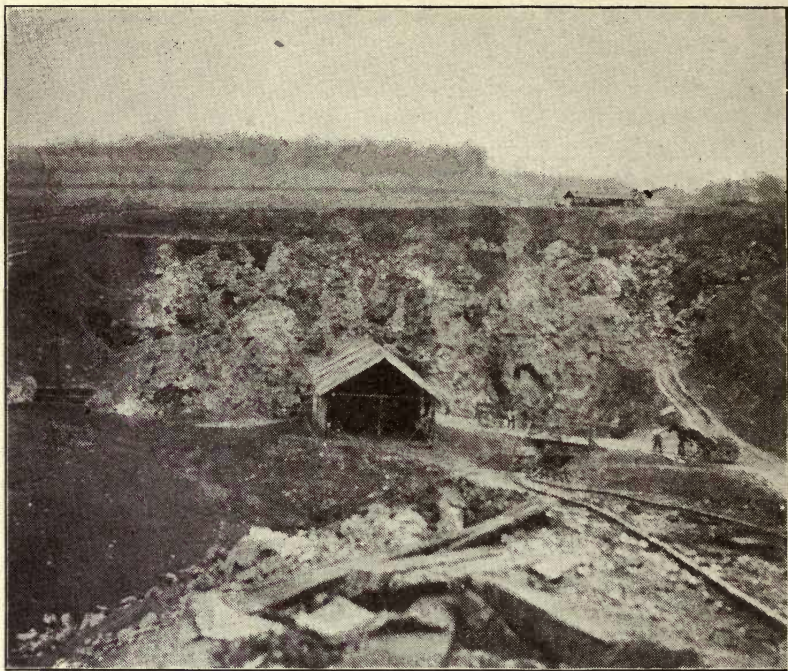


Fig. 1. The Grasselli Chemical Company's Zinc Quarry, Newmarket, Tenn.

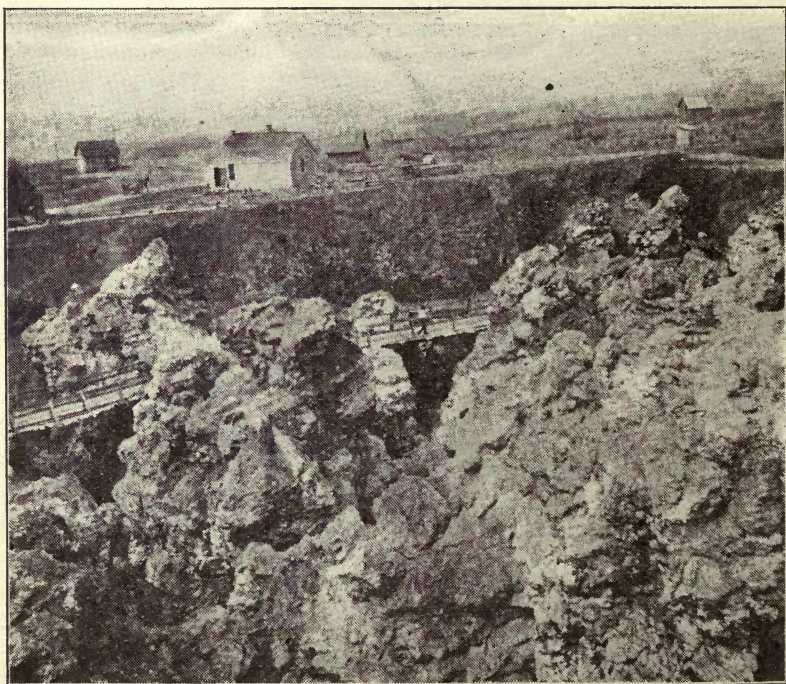


Fig. 2. The Grasselli Chemical Company's Zinc Quarry, Showing "Carbonate" Ore Diggings.

has taken over the property of the Newmarket Zinc Company (Plate III, Fig. 1 and 2), and has shipped some 95 carloads of carbonate ores to its smelters, under the able management of Mr. W. A. Underhill. This property has now been operating over a year, and is one of the most extensive mining operations in this district. They mine their ores with the steam shovel, and are now planning an extensive enlargement of their mill. It is gratifying to have such well known zinc operators taking a hand in Tennessee mining.

The Osgood Exploration Company, of Knoxville, Tenn., has taken over a large territory, consisting of all the mines of the old Eades, Mixter and Heald Zinc Company, and some other properties, including a lease on all the properties of the Carson-Newman College, at Jefferson City (Plate IV), and the Holston Mine, at Mascot, Tenn., and is now developing these properties. They have three large steam drill rigs at work. The holes are 6 inches in diameter, and are anywhere from 75 to 300 feet deep (or more, if necessary, to find the ore), and while from 3 to 7 holes will frequently prospect a piece of land containing 40 acres, three times this number are frequently drilled. These holes make excellent wells for watering stock when no zinc is found.

The Roseberry Zinc Company started operations in 1900. Ore was quarried, hand-picked or sorted, and sent to the crude Joplin mill. In 1904 the company made the first successful attempt to develop the Tennessee ore bodies by drilling, as had been done in Joplin. The drill disclosed a large ore body, which was opened by sinking a shaft 200 feet deep. The ore was mined in large stopes with machine drills. The ore was only roughly sorted as fed to the mill. This property adjoins that of the Osgood Exploration Company, and has recently been taken over by the Grasselli Chemical Company, who expect to erect a large mill on it.

The Tennessee Mineral Company is operating their mine and mill at Newmarket, making regular shipment of zinc blende concentrates, under the management of Mr. Kenneth R. Ayer and N. Caswell Heine, President, 1 Liberty St., New York. Mr. John Cox is the Superintendent. A quarry or open pit has been made, 165 feet long, and 40 to 50 feet wide. The ore body was found at the surface and over the ore it has been opened 50 to 60 feet deep. The ore body is nearly horizontal, and is said to be 600 feet wide. The ore is in a brecciated zone, and several seams of blende of a foot to several feet in width will average high in zinc, although no doubt the entire ore body will average much lower, probably about the same as the rest of these ores when mined on a large scale.

The old works of this property consist of an open pit or quarry,



Fig. 1. Mossy Creek Zinc Quarry, at Jefferson City, Tenn., of the Eades, Mixter & Heald Zinc Co., now controlled by the Osgood Exploration Co.

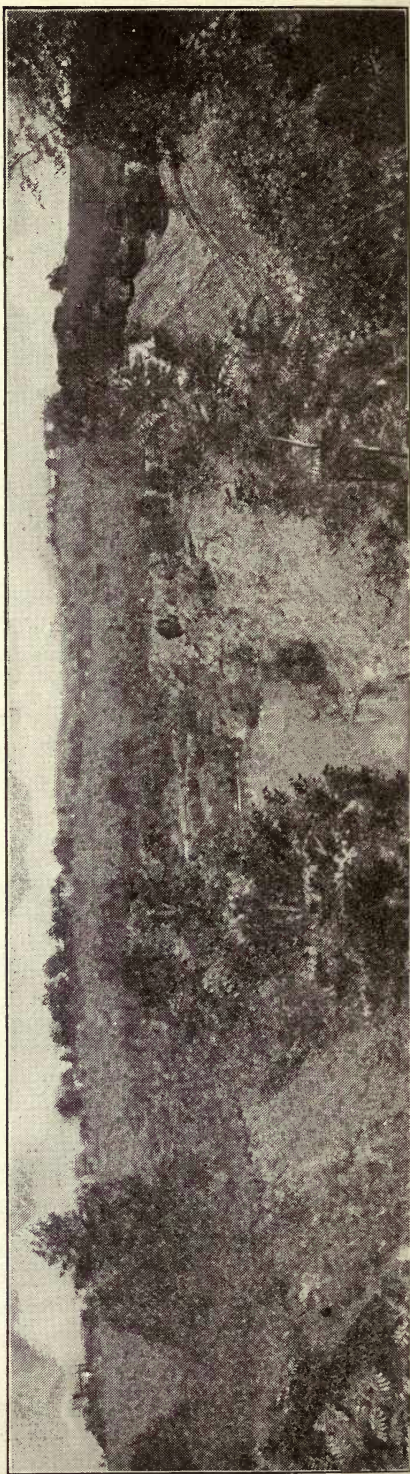


Fig. 2. The Branner Zinc Mine and Carson-Newman College Zinc Mine (looking from the Mossy Creek Mine), controlled by the Osgood Exploration Co., at Jefferson City, Tenn.

where the blende was mined for treatment in a small concentrator. The ore was mined and sorted in the quarry and hauled up an inclined track by a small hoisting engine. It was dumped upon a platform to be again hand-picked and then fed to the crusher. There were two quarries, 80 feet wide by 100 feet long, and about 5 feet deep. An old mill run shows that 500 tons of hand-sorted ore yielded 52 tons of concentrates, assaying 53 per cent zinc, which is very fair, considering the crude equipment of the mill. The new mill has been enlarged and rebuilt, and an aerial wire-rope tramway built for the efficient handling of the ores from the bottom of their large quarry to the top of the mill bins. From these the ore runs automatically by gravity through the mill, where the zinc concentrates are prepared for the smelters. On account of the extreme purity of these ores, they bring about \$2.00 more than the regular Joplin prices.

The Valley Mine is the best looking of the partially opened, but inoperative mines of the belt. This mine is at Friends, on the Southern Railway, 14 miles from Knoxville. The ore body is opened by an open quarry about 50 feet long, 15 feet wide, and 10 feet deep. The quarry is near Lost Creek, and the blende appears at the surface of the ground where the creek has washed away the soil. The ore occurs in a brecciated fissure zone, and is in appearance identical with the Mascot and Newmarket ores. Carbonate ores have been shipped from the clays of the subsoil on adjoining properties, which seems to indicate a large ore body on this property.

The Loves Creek Mine, at Loves Creek, 5 miles from Knoxville, was partially explored several years ago, and good ore was found. A 50-foot drill hole showed ore all the way to the bottom. There is a good mill site with ample water for milling and good surface indications. This is at present among the inoperative properties, but the owners expect to develop it into a mine.

Throughout the entire length of the zinc range from Knoxville to Jefferson City, wherever a creek has washed its way through the soil in crossing the ore zone good blende may be seen in the bed of the creek.

#### SUCCESSFUL MILLING OF TENNESSEE ZINC ORES FULLY PROVEN.

To Mr. A. M. Hewlett, the former President of the Kewanee Tube Company, now a part of the National Tube Company, belongs the credit of first solving the successful methods for the treatment commercially of the East Tennessee zinc ores. It cost the owners of the Holston Mine \$150,000 to solve this problem, and finally they evolved a mill under the direction of the Knoxville firm of mining engineers,

Osgood, Carter & Company, which gave commercial recoveries that for years the lack of had prevented the operation of Tennessee zinc mines.

They demonstrated that a 1,000-ton mill of correct construction would produce at a cost of \$20 per ton, 40 tons of concentrates, assaying 55 per cent zinc, worth \$31 per ton gross at the works, and that such a plant, in a going condition, would cost \$100,000, additional to the cost of the land. These figures are based on actual results of operation, conducted on the largest scale ever operated in this district. That this district can furnish ore in large quantities for several such mills, for years of continuous operation, is recognized by those familiar with the great magnitude of the ore bodies.

The large size of the ore bodies gives the Tennessee zinc field more of the aspect of a manufacturing proposition with its enormous supply of the raw material. Now, that it has been proven possible by modern means to successfully treat these ores, it remains merely to provide facilities, such as mills, steam shovels, crushers, etc. The range of zinc ore-bearing land comprises a strip a few hundred feet wide, nearly paralleling the main line of the Southern Railway that runs between Chattanooga and Bristol for a distance of 25 to 30 miles. This strip containing the ore bodies, varies from 6 to 50 feet wide, as is shown to be the case where it has been opened in a number of places for 20 miles in length, by a large number of drill holes, shafts with underground workings, as stopes and rooms and large open-surface quarries. These quarries are 30 to 60 feet deep, 30 to 100 feet wide, and 100 to 300 feet in length, all in ore. These ore bodies occur near the surface of the ground, and can be mined in large open quarries by steam shovels, after the manner of the Mesabi Range iron ores, with a simplicity that will make available the local supply of Southern labor, that will give extraordinary low costs of mining, comparing favorable with Mesabi Range costs. On the basis of 1,000 tons per day, it is estimated that the costs of mining and transporting to the mill will be near 20 cents per ton of ore, which will be recognized as being far below the costs possible in the Missouri or Wisconsin, or other zinc mines.

The average grade of this Tennessee zinc ore, especially that in the Holston River range, to which this refers, can be called a 60 per cent blende or "jack," or zinc ore proposition, meaning an ore which assays 4 per cent metallic zinc, and which in milling with a 60 per cent saving, will mill out as a 4 per cent ore; meaning that for every 100 tons of ore treated, a yield of 4 tons of concentrates will be obtained. These average figures of grade and milling results are based on the actual performance of practical large scale operations, and are not estimates

loosely made, but closely worked out results of such operations on a scale of 120 tons per day of this ore.

In the Joplin district of Missouri, 3 per cent "sheet ground" is considered to be a good paying proposition, worked on a scale of over 400 tons per day, and the ore bodies are only from 3 to 60 feet thick. Most of the "sheet ground" averages much less than 3 per cent, and runs as low as 1.35 per cent, are worked profitably from a 12-foot thick ore body, and milled at the rate of 600 tons per day, whereas, as above, East Tennessee ore is in large bodies and of a higher average grade for the large area.

At Aurora, Mo., Osgood, Carter & Company recently inspected a property operated by the Federal Lead Company, where they are milling a 2.63 per cent zinc ore at profit. This is about 30 miles from Joplin, and shows what can be done with lower grades and smaller bodies of zinc ores than are available in Eastern Tennessee.

In the Wisconsin zinc district, where Osgood, Carter & Company formerly operated large zinc mines and mills, the ore bodies are smaller, and the ores are higher grade. The richness of the ore bodies compensates to some extent, on an average, the low costs of mining Tennessee large ore deposits. For instance, the Wisconsin zinc ore body may average 15 per cent zinc, the ore may be only 1 foot thick, whereas a Tennessee ore body of 4 per cent grade may be 50 feet thick.

The ore from all of the above districts, excepting the Tennessee district, contains iron and lead as well as zinc. Shipments of carloads of 30 tons each in large quantities of Tennessee zinc concentrates show a record of 0.5 per cent to 1.5 per cent iron, and no lead, and such concentrates are in great demand for especially pure grade of spelter or metallic zinc.

#### THE SMELTING OF TENNESSEE ZINC ORES IN TENNESSEE.

The smelting of Tennessee zinc ores in Tennessee is inviting commercially, as is shown by the results of operation of the small smelter at Clinton, operated by the Eades, Mixter & Healds Company. Coal supplies in great abundance are procurable from many mines within 40 miles, having a railway freight rate of 75 cents, less than the 85 cent rate from the Joplin mines to the Kansas gas belt zinc smelters. The freight rates on the finished slabs of zinc also is less from Tennessee to New York and the Atlantic coast seaboard points of consumption than from the Western smelters. The market for sulphuric acid, the chief by-product of a zinc smelter, is close to Clinton, large amounts being used by the southern fertilizer works in Middle Ten-

nessee. The Tennessee Copper Company, only in March last, closed a large contract with the fertilizer combination for all the sulphuric acid it could produce, which combine also uses large quantities of acid that are now shipped in from the northern smelting points in Illinois, Ohio and Kansas.

The grade of spelter or metallic zinc made from Tennessee ores is unusually pure, and is said to have always brought at least 2 cents per pound more than the standard market price for other spelters, such as the western brands. The following chemical analysis of spelter that was made at the Clinton smelter (closed during the panic of 1893 and never reopened) shows an exceptional high grade.

(1) Analysis made at Boston by State Assayer S. P. Sharpless:

	Per Cent.
Zinc .....	99.723
Lead .....	0.238
Iron .....	0.039

Sample is free from arsenic, antimony, manganese and other impurities.

(2) Analysis by Ledoux & Rickets, of New York, in duplicates:

	Per Cent.
Zinc .....	99.988
Iron .....	0.017
	<hr/>
	100.000

Sample free from lead, copper, cadmium, arsenic, antimony, sulphur, etc.

Comparative figures will show the profits of zinc smelting in Tennessee to be proportionately greater than is now being made in the Kansas smelters close to the Joplin, or other Missouri zinc fields.

The net profits of smelting 40 tons of Tennessee concentrates daily amounts to \$540, and the installation of a plant of this capacity would cost about \$100,000.

East Tennessee as a field of investment in the zinc industry is thus shown to be one of great possibilities. The chief features of the inviting outlook for capital is the size of the ore bodies and the consequent assurance of a supply of raw material to last for years.

TABLE OF COMPARATIVE SMELTING PROFITS.

## JOPLIN SMELTERS PRACTICE

with 95% furnace efficiency :	LB.
1 ton of ore assaying 60% zinc contains metallic zinc or spelter amounting .....	1,200
Furnace efficiency (saying) 95%, or amounting to salable slabs of zinc ..	1,140
Value at New York with 5-ct. spelter .....	\$57 00
Cost of ore .....	\$40 00
Cost of smelting and freight .....	\$11 00
	<hr/>
	\$51 00
Net profits from zinc...	\$ 6 00
Profits from acids at least .....	\$ 6 00
Total net smelting profits, per ton.....	\$12 00

## TENNESSEE ZINC SMELTING

with 90% furnace efficiency	LB.	with 95% furnace efficiency	LB.
1 ton of ore assaying 55% zinc contains metallic zinc or spelter amounting .....	1,100	Same .....	1,100
Furnace efficiency (saying) 90%, or amounting to salable slabs of zinc ..	990	Furnace efficiency 95%, gives salable spelter..	1,045
Value at New York with 5-ct. spelter .....	\$49 50	Value at New York with 5 ct. spelter.....	\$52 25
Cost of ore .....	\$31 00		
Cost of smelting and freight .....	\$11 00	Same costs .....	\$42 00
Net profits from zinc...	\$ 7 50	Net profits from zinc...	\$10 25
Profits from acids at least .....	\$ 6 00	Profits from acids at least .....	\$ 6 00
Total net smelting profits, per ton.....	\$13 50	Total net smelting profits, per ton.....	\$16 25

## Some of the Principal Articles on Zinc in Tennessee.

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